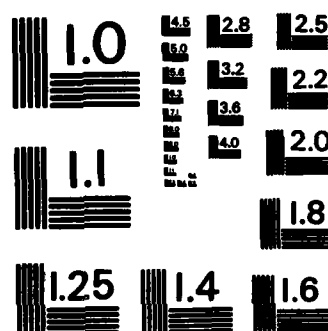END

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The position of the earth's spin axis with respect to the crust (polar motion) has been determined from Doppler observations of Navy Navigation Satellites by the Naval Surface Weapons Center and by the Defense Mapping Agency (DMA) since 1969. An international program to perform such computations was organized by the Centre Nationale d'Etudes Spatiale (CNES) in 1977 using somewhat different observing sites and computational procedures. Studies show that the observing locations used by the CNES are not adequate to determine pole position to an accuracy comparable to the DMA

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determinations. The use of the DMA station network results in a significantly improved determination of polar motion over the network used in CNES computations. An even greater improvement over CNES results is seen with the use of the DMA gravity field.

FOREWORD

In 1969, the Naval Surface Weapons Center began routine determinations of the position of the earth's spin axis with respect to the crust (polar motion). Polar motion values were determined on the basis of Doppler observations of Navy Navigation Satellites made by equipment deployed by the Defense Mapping Agency (DMA). These computations have been made at two day intervals, usually for two satellites. For over ten years, the Defense Mapping Agency Hydrographic/Topographic Center has determined polar motion values as a by-product of computations made to obtain precise satellite orbits. The precise orbits are in turn used to determine the geodetic positions of various sites at which mobile equipment is deployed.

Since the polar motion results have proven valuable to astronomers, the Centre Nationale d'Etudes Spatiale (CNES) proposed that an international program be organized to make such computations. This would insure that the service be continued in the event that DMA terminates its work at some point in the future. The proposal by CNES resulted in the formation of the project "Motion of Earth by Doppler Observation Campaign" (MEDOC), recognized by the International Astronomical Union (IAU) and the International Association of Geodesy (IAG). This report presents the results obtained from a study initiated to determine the effect on pole position results of differences in DMA and CNES procedures.

Approved by:

O. F. BRAXTON, Head
Strategic Systems Department

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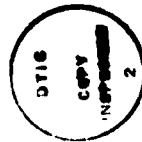
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CONTENTS

INTRODUCTION

Computations of pole positions by the Defense Mapping Agency Hydrographic/ Topographic Center (DMA) are made on the basis of Doppler observations of Navy Navigation Satellites obtained at the sites shown in Figure 1.[1,2] The computations are performed using a representation of the earth's gravity field designated "NWL10E-1". NWL10E-1 was determined in 1970 on the basis of Doppler observations of various satellites, although approximately half of the observations used were of Navy Navigation Satellites. Pole positions computed by the Centre Nationale d'Etudes Spatiale (CNES) are based on observations of the same satellites as DMA, but at the sites shown in Figure 2. The observations at eight of these sites are the same as those used by DMA. Two sites are at similar locations but use different observing equipment. The CNES uses the Goddard Space Flight Center definition of the earth's gravity field designated "GEM 10". The GEM 10 model was developed in 1978 on the basis of observations of various satellites and surface gravity measurements. However, a small number of these observations were of polar satellites like the Navy Navigation Satellites.[3]

The DMA pole positions have a random error of about 70 cm for each two-day solution. The CNES results have a random error in excess of 1 m for comparable data spans. Therefore, a study was initiated to determine to what extent the difference in self-consistency of results was due to the use of:

      (1) different station arrays
      (2) different station equipment
      (3) different geodetic systems for station locations
      (4) different gravity field used in computations, and
      (5) other differences in computational procedures.

Since the use of different representations of the earth's gravity field was thought to be the principal source of differences, this factor was studied first.

ANALYSIS AND RESULTS

A station array was selected which was no larger than the MEDOC array (Figure 3). The array included seven stations common to DMA and MEDOC, and DMA stations in England and Samoa. The DMA Brazil, South Africa and Samoa stations take the place of nearby CNES stations at Brazil, South Africa and Tahiti, respectively. Two sets of orbit computations and pole positions were performed for ten two-day spans from observations of Navy Navigation Satellite 60, days 263 to 282 in 1980. One set of computations was based on the GEM 10 gravity model and one set was based on the NWL10E-1 gravity model. Computational procedures for both cases were otherwise the same as those used by DMAHTC. The two sets of pole position results and those from the routine DMAHTC processing
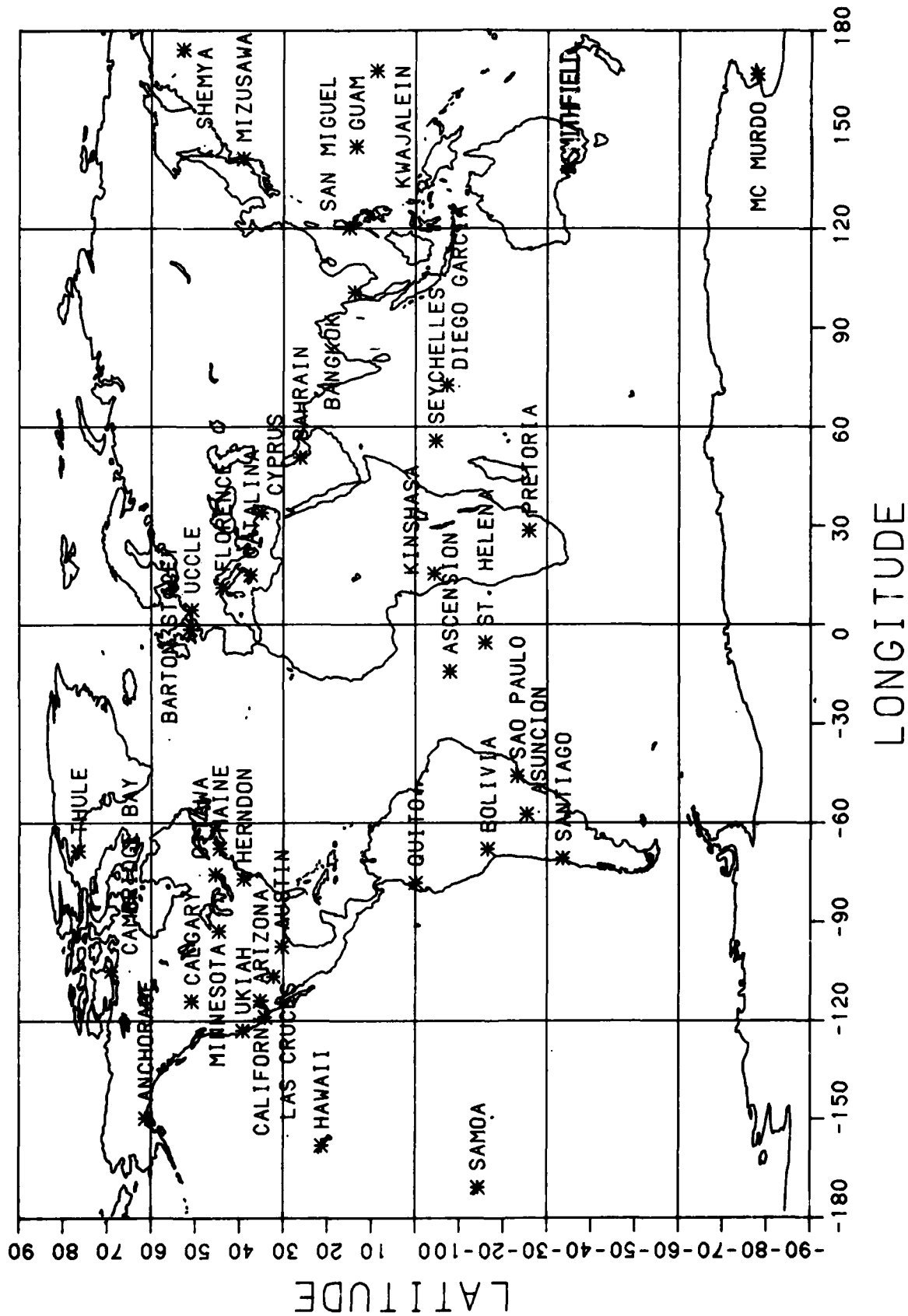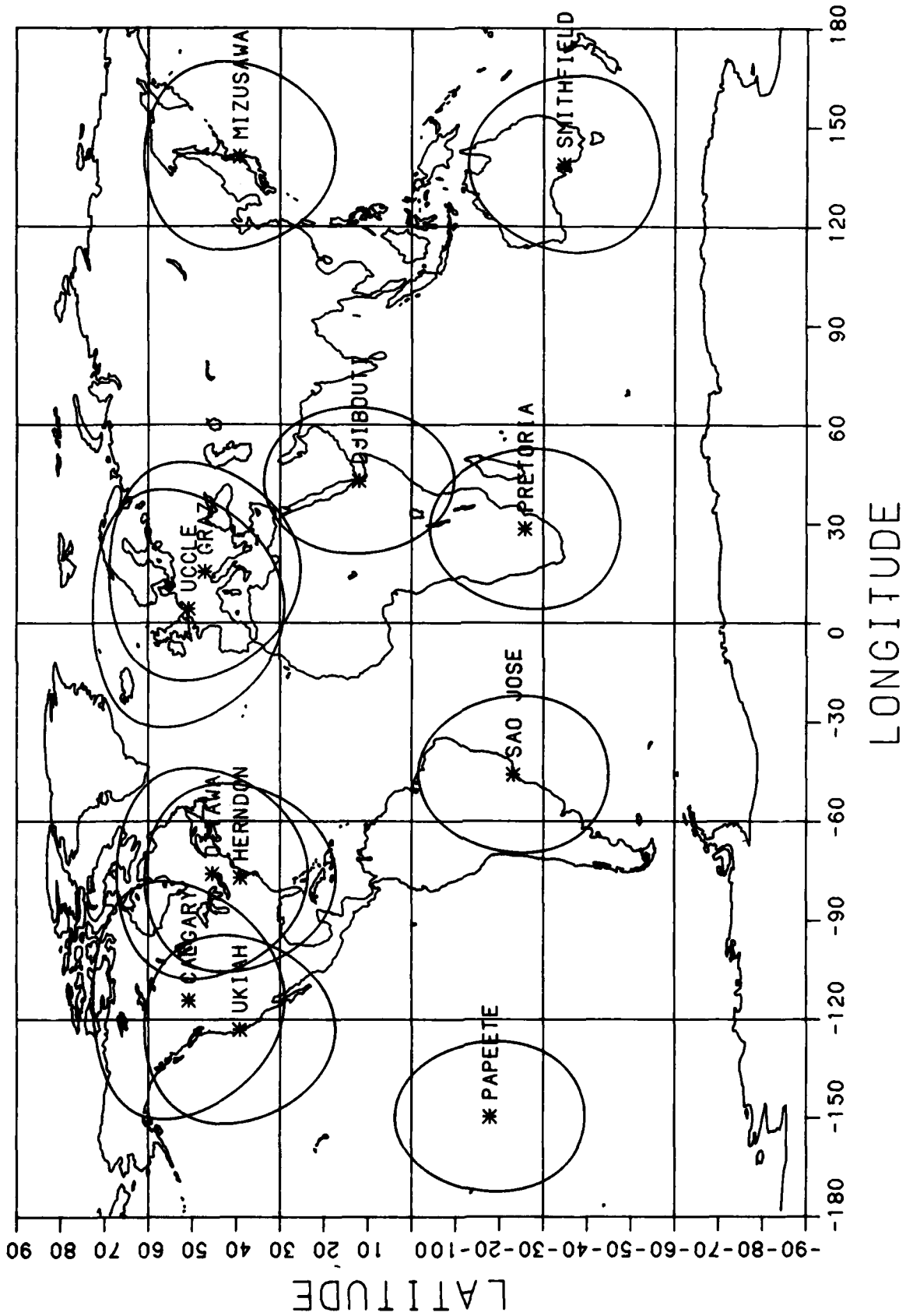
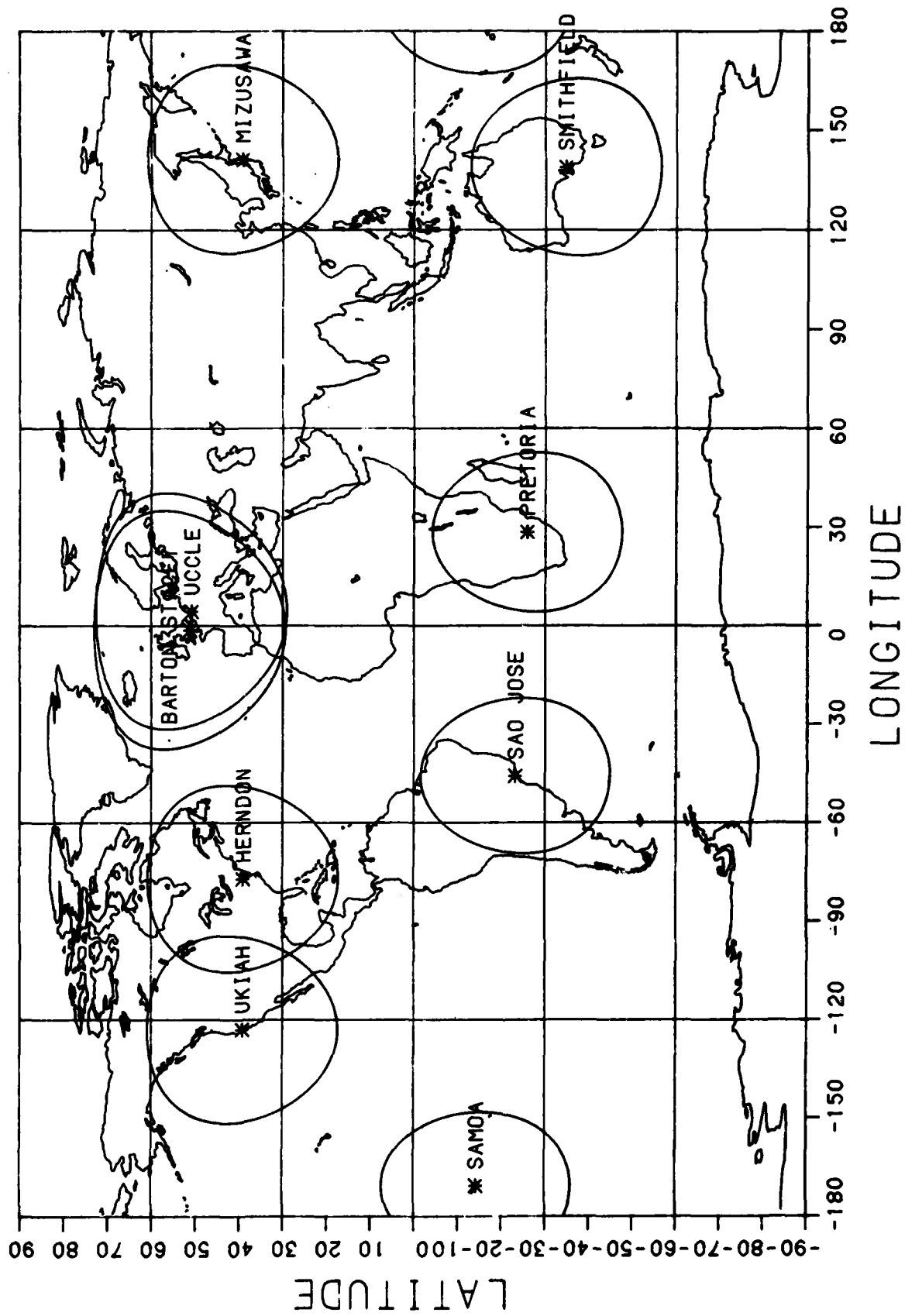FIGURE 1. DMA STATION NETWORK

FIGURE 2. MEDOC STATION NETWORK

FIGURE 3. SIMULATED MEDOC STATION NETWORK

are plotted with respect to the Bureau International de l'Heure (BIH) Circulaire
D values in Figure 4. A summary of the comparisons is given below:

Difference from BIH Circulaire D (cm)

	MEAN		STD. DEV.	
	x	y	x	y
DMAHTC	-38.9	19.6	38.2	44.4
MEDOC array, GEM 10	-38.8	141.1	105.0	156.6
MEDOC array, NWL10E-1	-66.0	94.8	51.4	85.6

The scatter in the GEM 10 results is comparable to that found in routine MEDOC
processing.[4]

CONCLUSION

The higher random error in the pole positions computed from the MEDOC data
as compared to that found in the DMA computations is primarily due to the
gravity fields used by each, with a significant contribution from the size of
the station network. DMA uses the NWL10E gravity model, while the MEDOC
computations use the GEM 10 model. The use of the NWL10E field with the
simulated MEDOC station network instead of the GEM 10 field reduces the scatter
by a factor of two. With the larger DMA station network, the scatter is further
reduced by a factor of two.

Any additional influences of different types of equipment used at some
sites or of differing methods of data processing have not been considered in
this study. Biases seen in the plots of Figure 4 were ignored in analysis, but
are probably equivalent to the differences in pole origin. They may, however,
reflect a longer period variation (over 10 days) in computed pole positions.
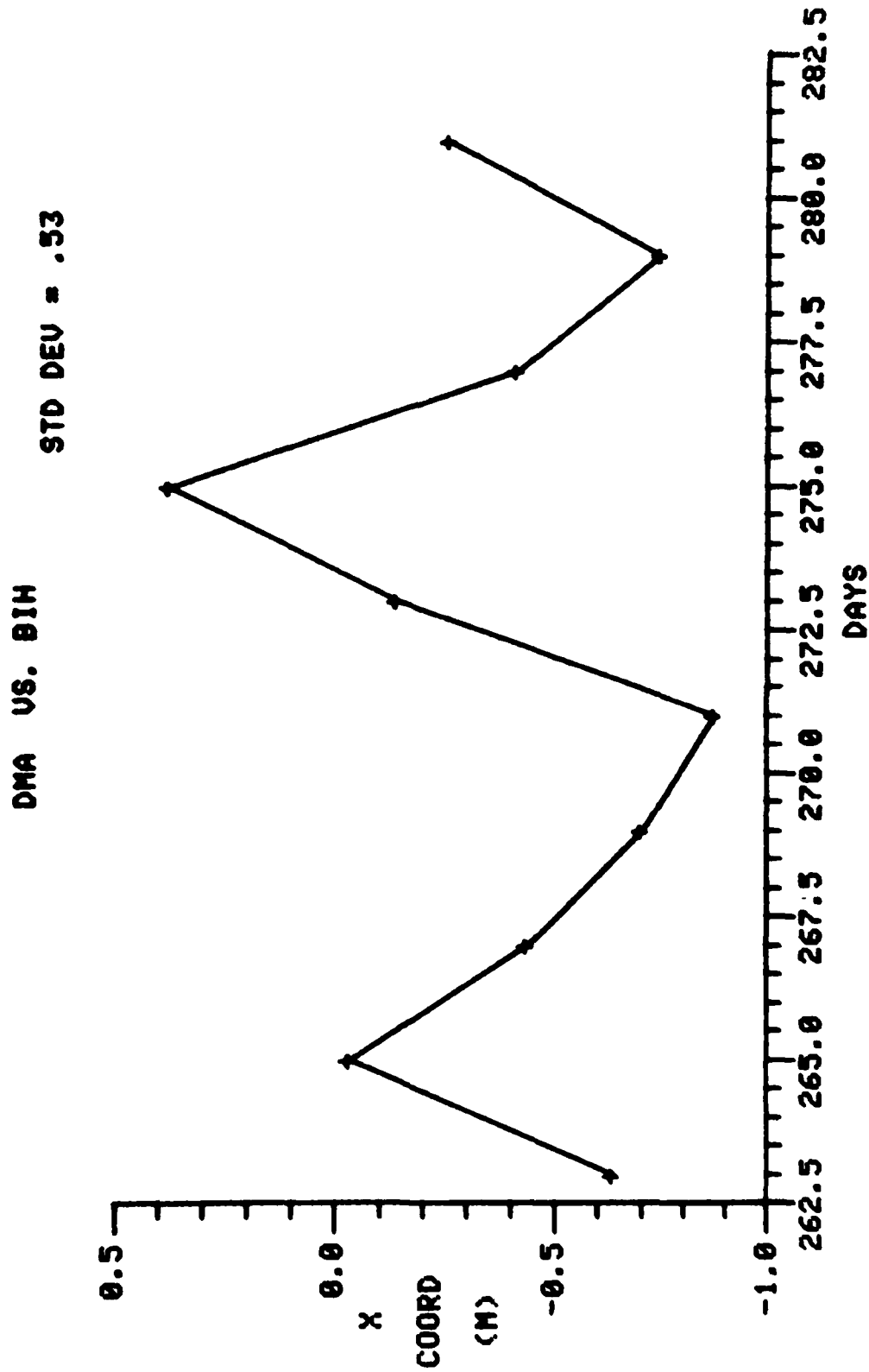
FIGURE 4A. POLE COMPARISON

FIGURE 4B. POLE COMPARISON

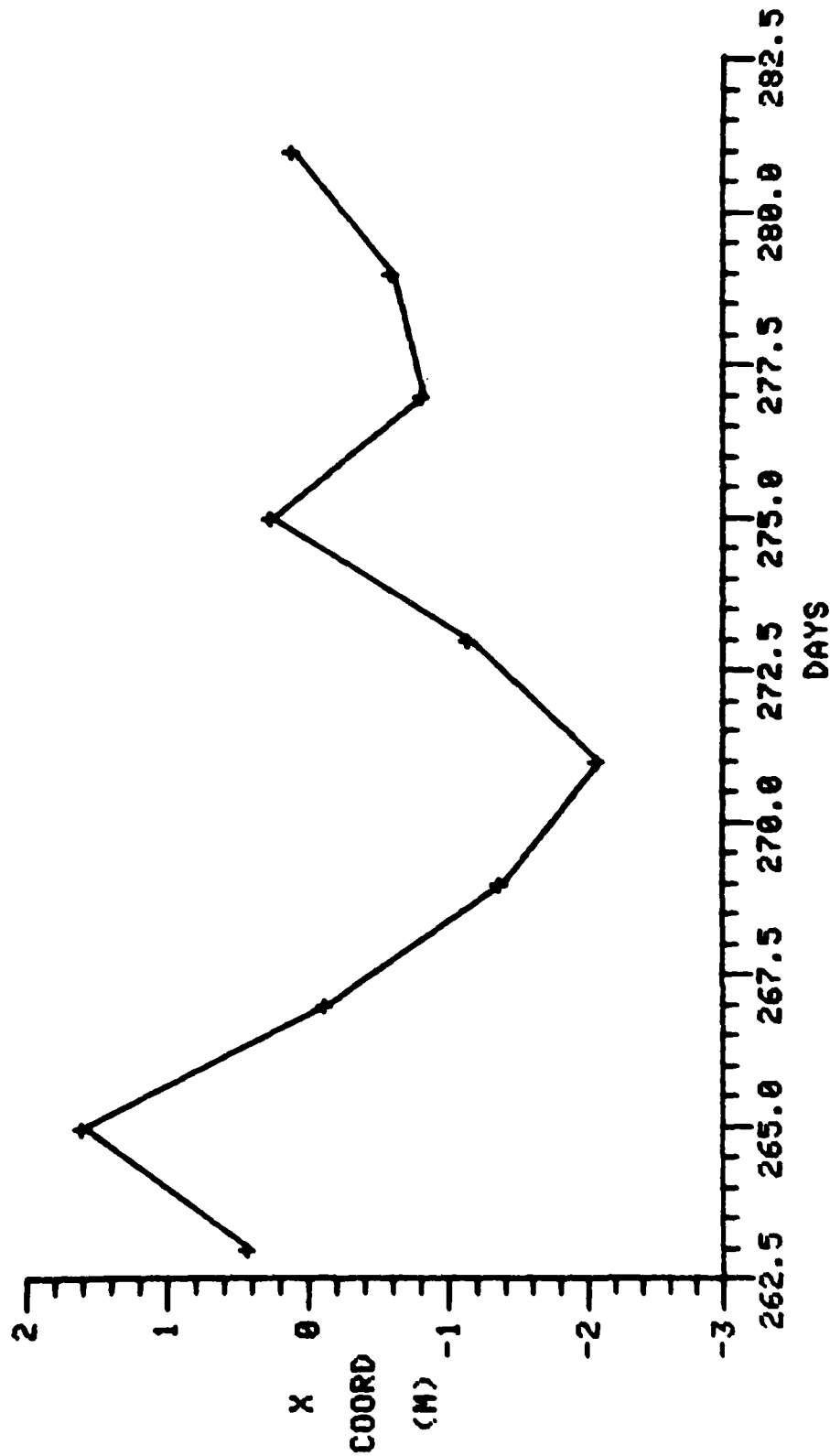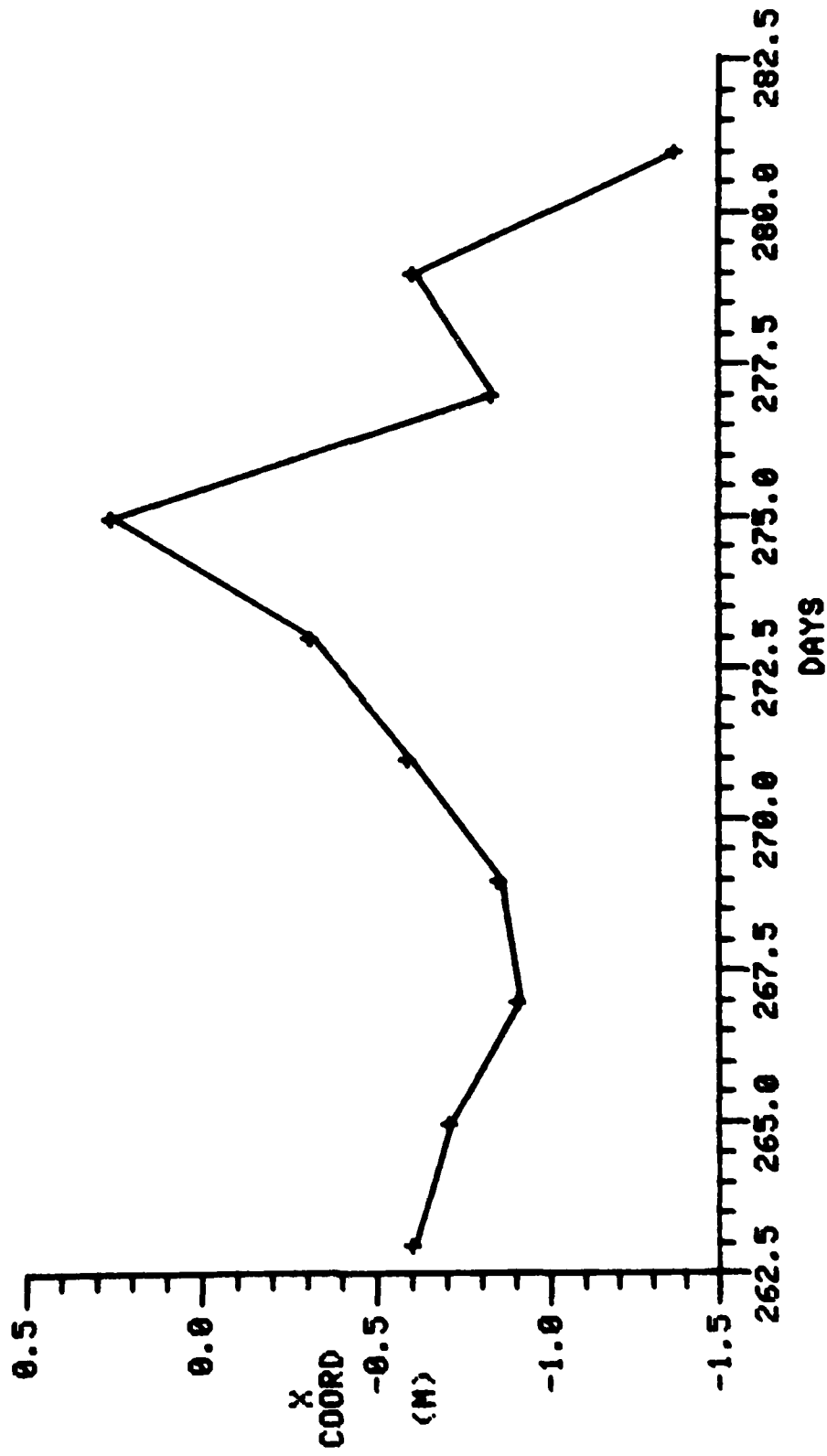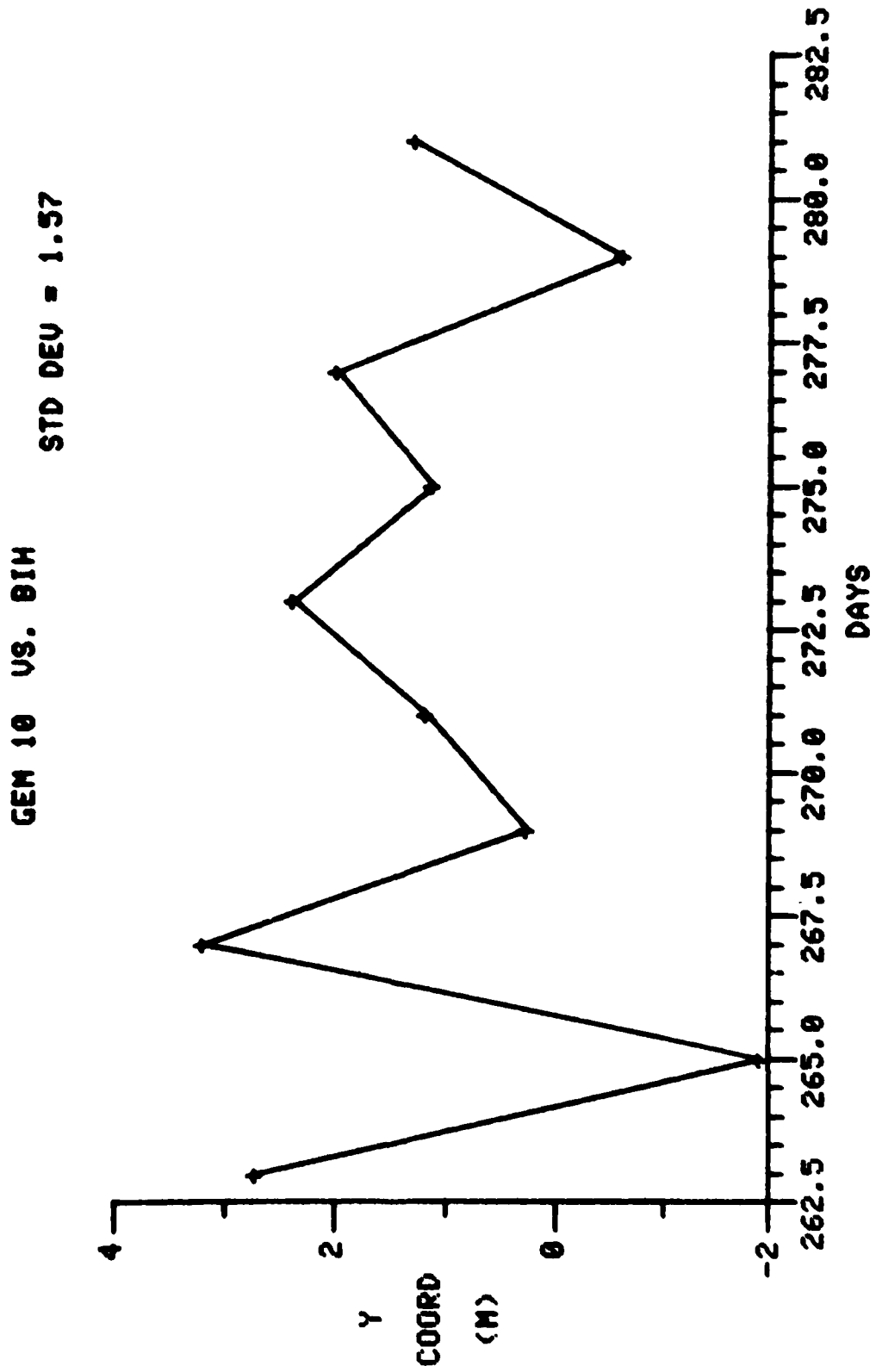FIGURE 4C. POLE COMPARISON
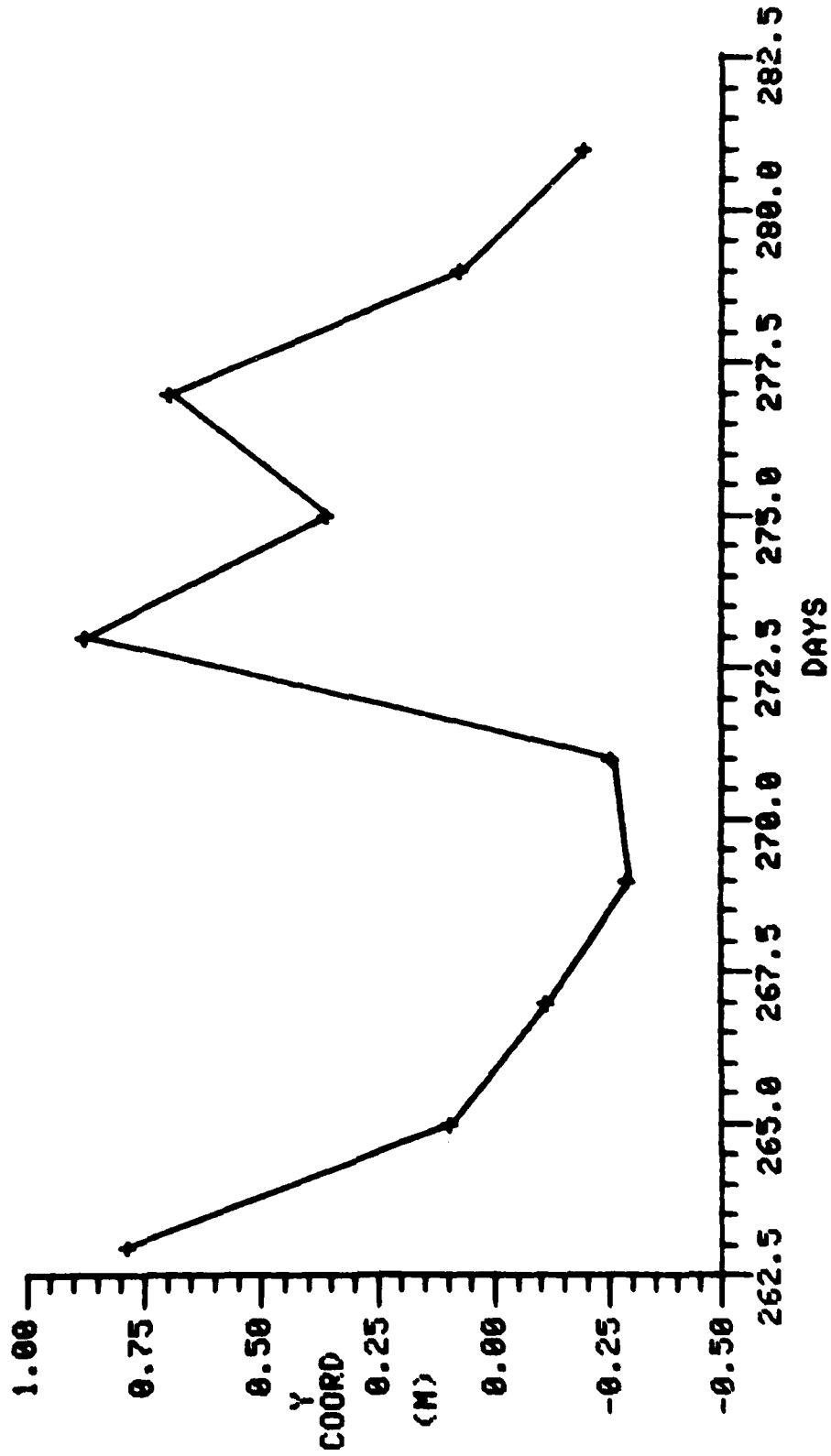
FIGURE 4D. POLE COMPARISON

GEM 10 VS. BIH   STD DEV = 1.57
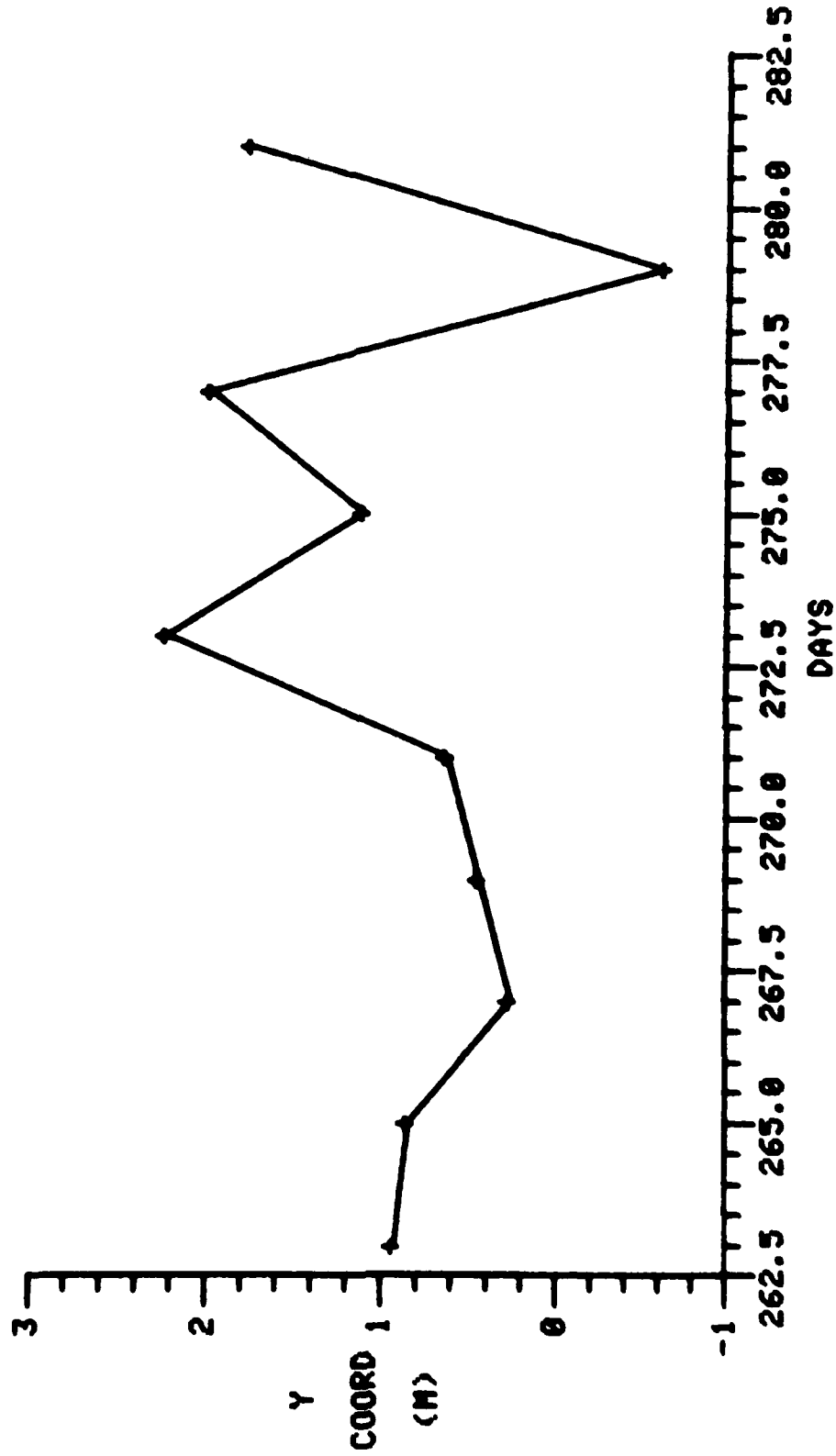
FIGURE 4E. POLE COMPARISON

FIGURE 4F. POLE COMPARISON

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